

Andhracoides shabuddin gen. nov., sp. nov., a new phreatoicidean isopod (Crustacea, Hypsimetopidae) from hypogean aquatic habitats in Andhra Pradesh, India

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Abstract

A decade-long survey of ground waters in the state of Andhra Pradesh, India, has so far yielded over sixty new crustacean taxa, belonging to Copepoda, Bathynellacea, Amphipoda, Isopoda, and Ostracoda. This paper describes a new genus and species attributable to the phreatoicidean isopod family Hypsimetopidae Nicholls, and provides ecological and behavioural observations. The new taxon was found in Guthikonda Cave, which is about 8 km from Piduguralla town in the Palnadu area of Andhra Pradesh State. The species belonging to this clade are unusual in that their dorsoventrally flattened pleotelson gives them a non-phreatoicidean appearance. Because the postanal margin is missing, as in other members of the Hypsimetopidae, this is a superficial similarity rather than homology with other isopods. Other unusual features include robust blunt denticles on opposing margins of the pleotelson and protopod of the uropods. The species in this clade, of which *Andhracoides shabuddin gen. nov., sp. nov.* is only the first to be described, are related to *Nichollsia* Chopra & Tiwari, found in northeastern India, and to *Pilbarophreatoicus* Knott & Halse from the Pilbara region of Western Australia. The new species differs from its undescribed congeners in being nearly devoid of dorsal setae; other species of *Andhracoides gen. nov.* are much more hirsute.

Key words: Phreatoicida, cavernicolous, groundwater, systematics, ecology

Introduction

Chopra & Tiwari (1950; Chopra, 1947; Tiwari, 1955a) introduced the remarkable hypogean isopod genus *Nichollsia* Chopra & Tiwari, 1950, to crustacean biology, and confirmed the Gondwanan affinities of the Phreatoicidea by its presence in India. Since these initial reports, no new species of the suborder Phreatoicidea have been described from India. Currently, *Nichollsia* has just two species: *N. kashiense* Chopra & Tiwari, 1950 and *N. menoni* Tiwari, 1955. The genus was initially assigned to the family Nichollsidae Tiwari, 1955a, although its affinities led Wilson & Keable (2001) to assign it to the family Hypsimetopidae Nicholls, 1943 (originally proposed as a subfamily of the Amphisopidae). Since that time, these phreatoicids on the Indian subcontinent have attracted studies on their biology, morphology and phylogeny (e.g., Gupta, 1985, 1989; Tiwari 1952, 1962; Tiwari & Ram, 1972; Erhard, 1998, 1999). One of us (YRR) has been pursuing research on the groundwater crustaceans, especially copepods and bathynellaceans, in Andhra Pradesh over the last decade (e.g., Ranga Reddy, 2001; Holsinger et al., 2006; Ranga Reddy & Totakura, 2010). The samples collected under the auspices of an ongoing major research project have yielded, inter alia, a new phreatoicidean cavernicolous isopod, which is related to, but distinctly different from the North Indian genus *Nichollsia*. To open a new chapter in our knowledge of the Indian Phreatoicidea, we introduce this new isopod as *Andhracoides shabuddin gen. nov., sp. nov.* and provide a detailed description of its morphology using scanning electron microscopy (SEM). Evidence is presented to support the creation of a new generic level taxon, and the unique features of the morphology of *Andhracoides gen. nov.* are discussed in relation to other hypsimetopid genera.

Environmental setting and ecology

Description of the Guthikonda Cave. This cave (“Guthikonda Bilam” in the vernacular) is a large natural limestone cave, located at about 8 km from Piduguralla town in the Palnadu area of Guntur District of Andhra Pradesh State in southern India (Fig. 1). The cave (16°23'42.4"N, 79°49'38.97"E; elevation 160.7 m) lies at the foot of a hillock in the dense forests of the Nallamala Hills of Eastern Ghats. It is said to have about 11 chambers, with seven passages at the ground level. The south-facing entrance of the cave (2.3 m long, 1.5 m wide) is lined by reinforced concrete and paved with steps, leading into a spacious, descending chamber (c. 50 m wide, 15 m high, and 90 m long) (Gebauer, 2003). The huge and high roof descends more rapidly than the floor, giving rise to a pool of about 1 m depth. The roof is composed of rock with mica schist and limestone. The floor is uneven, with a thick layer of gravel and some huge boulders. No flow of the water was noticed. The cave attracts tourists during the weekends. During some Hindu festivals, pilgrims gather in large number and even swim or wade in the cave pools. No publications report on the biology of the cave. Some abiotic parameters, as determined on 16 January 2009, were as follows: air temperature 33°C; water temperature 25°C; pH 8.2; dissolved oxygen 6.2 mg/l; salinity 0.47‰; conductivity 713 µS; and turbidity 0.87 NTU.

Ecology. On all three occasions of sampling (27 December 2008, 16 January 2009, and 28 November 2010), *Andhracoides shabuddin gen. nov., sp. nov.* was abundant (approximately 40 and 100 specimens collected in two instances) and regularly encountered in the four or five chambers of the cave sampled, suggesting that the cave is its prime habitat. In the accompanying fauna, no other stygobionts were observed. The plankton samples of the cave pools, however, yielded a dense population of stygophilic/stygoxene cyclopoids (*Mesocyclops* sp.).

Behaviour. The species is ambulatory, which is also typical of *Nichollsia* species (Chopra & Tiwari, 1950; Gupta, 1989). The animals were found crawling along the shallow margins of the cave pools. When disturbed, they momentarily kept themselves suspended in the overlying water, and were thus caught by a plankton net (Fig. 1C). When left in the laboratory in a tray with some water, several specimens crawled out at night, fell on the floor, and were found dead some 3–4 meters from the tray atop a table, probably because of desiccation. This behaviour indicates that this species has a substantial ability to navigate aerial habitats in humid circumstances, as one might find in cave environments. Similar abilities have been noticed in other phreatoicidean isopods: *Eophreatoicus* Nicholls readily climbs rocky cliff-sides around waterfalls (Wilson et al., 2009); *Phreatoicopsis* Spencer & Hall is semiterrestrial and can crawl easily in aerial environments (personal observations); large numbers of specimens belonging to *Peludo* Wilson & Keable have been observed making migrations (P. Masters & T. Ross, pers. comm., Cape Le Grande, Western Australia; see <http://australianmuseum.net.au/search/?keyword=Peludo>). Though uncared for, the specimens of *A. shabuddin* remained alive in the laboratory for a week.

Distribution. Although the primary habitat for *Andhracoides shabuddin gen. nov., sp. nov.* is in open caverns, we have found additional species of *Andhracoides* in certain wells of Andhra Pradesh (Fig. 1D). These wells occur mostly in the deltaic area of the Rivers Krishna and Godavari.

Methods

The specimens were captured using a plankton net from the floor of the Guthikonda Cave. Other localities (Fig. 1D), were sampled by pumping water from wells through a plankton net. All specimens were examined using light microscopy and SEM. The holotype and multiple paratypes were photographed using a digital camera, and the resulting images processed into plates or used for measurements. Parts were dissected from paratypes in ethanol using a fresh piece of a razor blade held in a clamp. Sonication for 3–5 seconds was performed to remove debris and epibionts. The specimens were dehydrated in 100% ethanol, critical-point dried. The individual parts were vertically mounted on stubs using adhesive carbon spots, attached at the cut edge. For efficient imaging, multiple parts were placed on each stub so they could be viewed without obscuring other parts. The stubs were then gold-palladium sputter coated, and examined using an *Evo LS15* Carl Zeiss microscope. The SEM stubs are retained at the Australian Museum (see Materials Examined below). Figures were prepared either using *GIMP* (ver.2.6.6, <http://Gimp.org>) or *Adobe Photoshop* (ver.7.01, <http://www.adobe.com>). Backgrounds were deleted from each image, and the grey levels were adjusted for a consistent contrast. Measurements were made on digital images of specimens using graphics tablet (Wacom Co., Inc.) and the Java application *ImageJ* (Wayne Rasband,

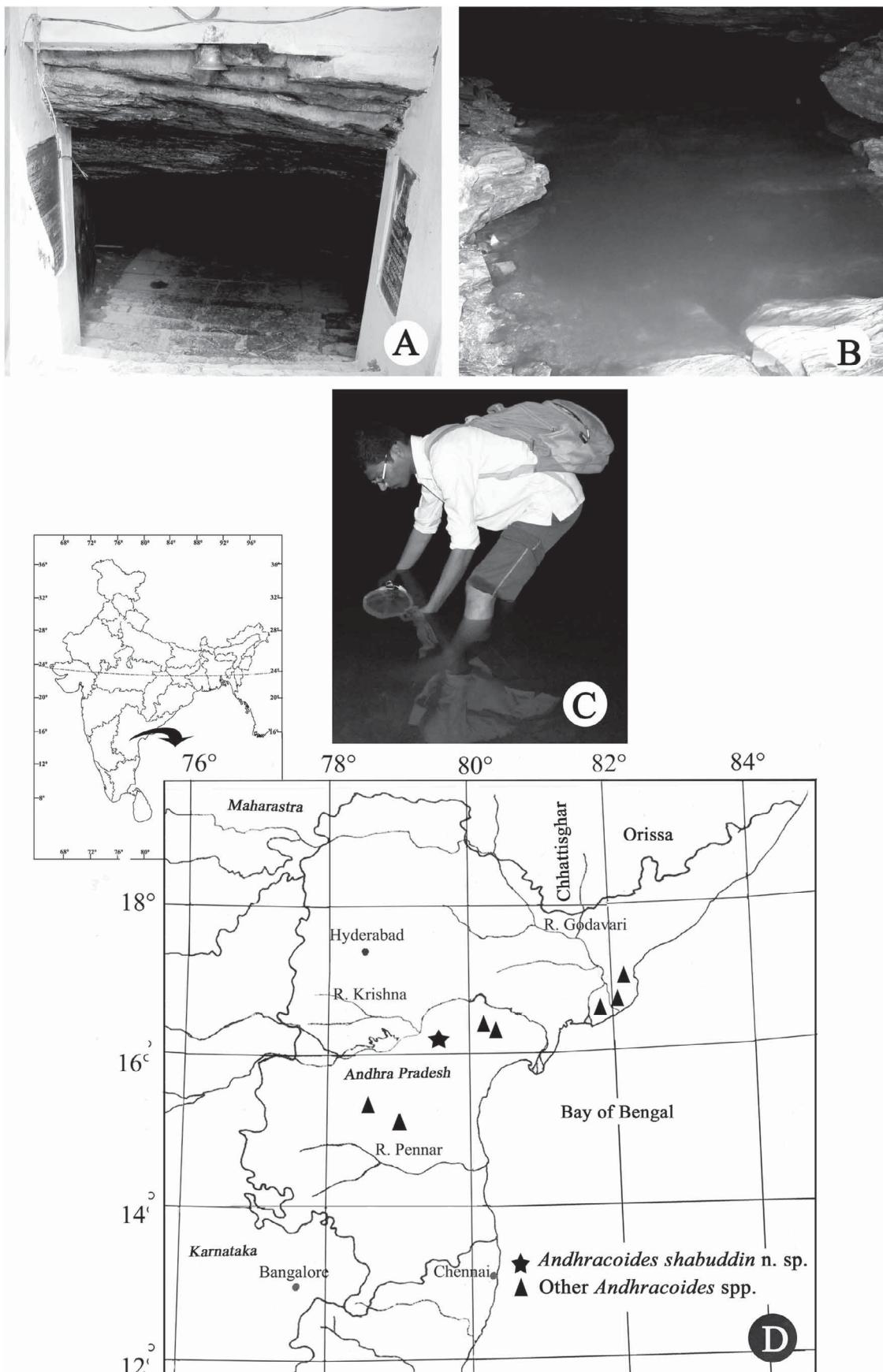


FIGURE 1. Guthikonda Cave (A–C): (A) cave entrance; (B) a cave pool; (C) method of collection; and (D) distribution map of *Andhracoides* species in Andhra Pradesh State.

<http://rsbweb.nih.gov/ij/>). The diagnoses and description were generated from a DELTA database (Dallwitz 1980, Dallwitz *et al.* 2000a, 2000b) and subsequently edited for clarity of language. In descriptions, measurements or ratios may be followed with identification of the specimen used for the measurement by the registration number, or by "H" for the holotype male. The term body length is indicated by "bl" in the descriptions. Abbreviations for institutions include "AM" for Australian Museum, and "ZSI" for Zoological Survey of India. Nomenclature and terms are those used in Wilson & Keable (2002; 2004).

Phreatoicidea

Hypsimetopidae Nicholls, 1943

Phreatoicidae.—Sayce, 1902: 218; Sheppard, 1927: 93.

Nichollsidae Tiwari, 1955a: 293.—Gupta, 1989:14 (part); Knott 1986:486 (part).

Hypsimetopinae.—Nicholls, 1943: 130 [subfamily of Amphisopidae].

Hypsimetopodinae.—Wilson & Keable, 2001: 184.

Hypsimetopodidae.—Wilson & Keable, 2002: 43; Poore *et al.*, 2002: 62; Harvey, 2002: 559; ABRS, 2009.

Hypsimetopidae.—Knott 1986: 486 (part); Wilson & Keable, 2004: 741; Wilson, 2008: 303.

Type. *Hypsimetopus* Sayce, 1902

Genera included. *Andhracoides* gen. nov.; *Hyperoedesipus* Nicholls & Milner, 1923; *Hypsimetopus* Sayce, 1902; *Nichollsia* Chopra & Tiwari, 1950; *Phreatoicoides* Sayce, 1900; *Pilbarophreatoicus* Knott & Halse, 1999.

Diagnosis. Head without tubercles or eyes. Pereon without dorsal ridges or lateral tergal plates. Pleonites with small pleurae, depth in lateral view similar to pereonites depth, basal region of pleopods visible; pleonite 1 pleura near depth pleonites 2–5 pleurae; pleonite 5 dorsally smooth, without ridges or tubercles. Pleotelson dorsal surface smooth, without median or lateral ridges; lateral uropodal ridge absent; lateral length greater than depth, ventral surface anterior to uropods flattened, only slightly concave; postanal ventral surface absent; posterior apex free, not reflexed, without pairs of robust setae. Antennula with more than 6 articles in male (most Phreatoicidea), article 3 secondary flagellum absent, article 4 shorter than article 3. Antennal flagellum proximal articles without dense cover of cuticular hairs. Mandible palp article 3 relatively linear, with more than 5 setae on medial-distal margins, lacking coarsely spinulate setae; incisor processes broad, width greater than thickness; left lacinia mobilis with 3 cusps; right lacinia mobilis well separated and distinct from remainder of spine row; spine rows on projecting ridge between incisor and molar; left and right spine row with first spine not separated from remaining spines. Pereopodal coxae ring-like, without projections. Pereopod I propodus without robust palm; dactylus shorter than propodus. Pereopod IV in male propodus not sexually dimorphic (except in *Hyperoedesipus*), without distinct palm, distal width less than midpoint width; basis dorsal ridge not distinctly separated from basis shaft. Pereopod VII basis dorsal ridge distal margin indented. Penes cuticle smooth, lacking setae. Pleopod exopods II–V biarticulate, pleopod I uniarticulate; medial proximal lobes absent; endopods I–V without setae on margins; protopods I–V lateral epipods absent. Uropod protopod dorsomedial ridge medially directed, opposing denticulate posterior margin on pleotelson; protopod ventral ridge without rows of long laterally projecting setae.

Remarks. The above diagnosis is more extensive than previous versions (currently ABRS, 2009) because the implicit characters found in many phreatoicideans (e.g., antennula with more than 6 articles) have been incorporated. The DELTA database from which this diagnosis is derived (Wilson & Keable, 2004) also is more complete so more detail could be included. The suffixes for the family name have been somewhat unstable, owing to a strict correction to the family name (Wilson & Keable, 2001, 2002): the Latin genitive of ".isopus" was construed to be ".isopodis" so the family name was changed to Hypsimetopidae. ICZN (1999) allowed more freedom for the spelling of family names, so the original spelling of Nicholls (1943), which is preferable, has been used subsequently.

Because hypsimetopids dwell in hypogean zones, either deep in caves and aquifers or in surficial habitats like burrows or submerged roots, all species of the family are blind and typically have elongate antennae and thin bodies. Synapomorphies of this family are most evident in features associated with the pleon. Reduced pleonite pleurae expose the pleopods and make them appear substantially large, although the pleopods are not especially larger than in other genera, where they are hidden behind much larger pleurae. The pleotelson varies considerably among the

hypsimetopid taxa, but has several consistent features in all: the ventral surface anterior to the uropods is not strongly concave as it is in the other phreatoicideans, the uropodal ridge (extending from the posteroventral margin behind the uropods) is absent, and the terminal margin lacks a reflected tip with the postanal ventral surface being substantially absent. The anus is directly adjacent to posterior margin, which typically consists of the dorsal edge of the anal ring. Many species have denticles or teeth on the posterior pleotelson margin. The uropodal dorsomedial ridge projects medially so that when the uropods are retracted, the protopod opposes the pleotelson margin like a movable finger. This adaptation is most evident in the new genus *Andhracoides*, where both the uropodal protopod and the pleotelson margin have teeth that interdigitate. In *Phreatoicoides*, the medial side of the uropodal protopod is furnished with a dense group of digitate setae, and the dorsomedial ridge is reduced to a blunt medially projecting spine. The male pereopod I of all hypsimetopids has a weakly developed propodal palm, unlike other phreatoicideans where it is strongly sexually dimorphic, being inflated, robust, and generally furnished with one or several rows of robust spine-like setae. *Andhracoides gen. nov.* extends this hypsimetopid trend to having nearly complete absence of sexual dimorphism in the first pereopod, as well as pereopod IV. In other hypsimetopids, however, pereopod I becomes substantially enlarged, with the most modified propodus appearing in *Hyperoedipes*.

Andhracoides gen. nov.

Type species. *Andhracoides shabuddin*, sp. nov., here designated. Currently monotypic.

Etymology. The prefix of the generic name, “Andhra” alludes to the Andhra Pradesh State in peninsular India, where the new genus has been found. The Latin suffix for likeness “oides”, an adjective with one termination, with “c” retained, is taken from the hypsimetopid genus name *Phreatoicoides* Sayce, 1900. The gender of *Andhracoides* is considered masculine.

Diagnosis. *Head.* Frontal process above antennula (Fig. 3A; dorsal margin of antennal notch) not curved. *Pereon* pereonite 1 dorsal margin in lateral view shorter than on pereonite 2 (Fig. 2A). Pereonites 2–7 in dorsal view anteriorly longer than wide, decreasing posteriorly to wider than long. Coxal articulation to pereonites 2–4 nearly fused, 5–7 free. *Pleotelson* shallow (lateral fields sloping), lateral margin in dorsal view linear, broadening posteriorly (Figs 2D, 9A), dorsal surface in lateral view weakly curving, length substantially greater than width of uropodal insertion, lateral margin with fine setae only; posterolateral margin in lateral view uninterrupted, without distinct inflection differentiating apex, crenate, with 4 teeth, teeth rounded in cross-section (Figs 2D, 9D, G); posterior apex in dorsal view projecting posteriorly (not indented), dorsal margin of ventral anal ring projecting posteriorly (Fig. 9C); dorsal surface without setose tubercles. *Antennula* and *Antenna* elongate with numerous flagellar articles. Antennular distal articles (Fig. 3D) in cross-section circular; terminal article tubular, shorter than penultimate article; penultimate article not distinctly longer than other articles, width approximately subequal to antepenultimate article width. Antenna article 1 absent, article 5 longer than article 4, article 6 subequal to articles 4 and 5 combined (Fig. 3C, E). *Mandible.* Palp article 3 medial surface naked (Fig. 4A). Right lacinia mobilis with two dentate plates (smaller plate on anterior surface of larger plate) (Fig. 4E). Spine rows with bifurcate spines, forming strongly convex arc in ventral view, protruding medially, basal insertions curving dorsally to posteriorly (Fig. 9B–D). Molar process stout, heavily keratinised; complex setulate spines forming posterior row (Fig. 9D). *Pereopods.* Pereopod I not sexually dimorphic, male and female pereopods similar; dactylus without distal accessory spines (Fig. 6A–B); propodus without developed palm, margin convex to straight; without spines or rugose cuticular pad, cuticular fringe weakly developed; with only stout conical simple setae; merus distodorsal margin in cross-section shelf-like and U-shaped. Pereopods II–III (Fig. 6C–D) dactylus shorter than propodus, with 1 distal accessory claw and no additional distal spines; propodus without articular plate on posterior side of limb. Pereopods II–IV (Fig. 6C–E) basis lateral face ridge absent; ischium dorsal margin with simple setae, none robust. In male. Pereopod IV simple (not prehensile); propodus articular plate on posterior side of limb absent, basis dorsal ridge in cross-section angular and produced but not forming distinct plate. Pereopods V–VII (Fig. 7A–B) dactylus with accessory claw ventral to primary claw; propodus articular plate on posterior side of limb absent; basis dorsal ridge angular in cross-section, not distinctly separated from basis shaft, with no large setae; lateral face ventral ridge present, setae absent. Pereopod VII ischium dorsal ridge without flange. *Pleopods* II–V (Fig. 8B–F) exopod proximal article distolateral lobes shorter than distal article; exopod I lateral proximal lobe absent; endopods unilobed; without setae on margins; protopods medial margin coupling hooks absent. Pleopod II endopod appendix masculina (Figs 7D–E, 8C) geniculate, projecting laterally at base of appendage; basal musculature pronounced; proximal half of shaft

broadly concave in ventral cross-section, not forming tube; distal tip acutely rounded, margins smooth; medial and lateral margins with stiff elongate setae. *Uropod* (Fig. 9A–B, F–H) protopod margin with rounded denticles, dorso-medial ridge in dorsal view parallel to ventral margin, robustly curving to oppose pleotelson posterior margin, distomedial margin without spinose or robust setae. Endopod subequal to protopod length, straight dorsally, dorsal margin without robust setae or spines on dorsal margin.

Remarks. This genus was originally thought to be part of the *Nichollsia* clade, but its pleotelson is sufficiently divergent that we have assigned it to a new genus in the family Hypsimetopidae Nicholls, 1943. *Nichollsia* has two similar described species *N. kashiense* Chopra & Tiwari, 1950 and *N. menoni* Tiwari, 1955 (although *N. menoni* would benefit from a revision). Moreover, we have found that the morphology described above applies to several undescribed species of *Andhracoides* gen. nov., found in Andhra Pradesh. The general pleotelson form of this genus, being flattened and broadening posteriorly with a well-developed terminal tip, is unlike any other hypsimetopid, which are either indented or at least transverse in dorsal view. Indeed, *Andhracoides* is unique among the Phreatoicidea in having a pleotelson that is not strongly vaulted, and therefore much more like other isopods in being rather flattened. We do not think, however, that this condition is basal because the pleotelson is similar to that seen in other Hypsimetopidae; for example, the postanal margin, which is present in other phreatoicideans and members of other families, is missing, as is typical for other members of this family. The terminal projection of *Andhracoides* is an extension of the anal ring and, like many other hypsimetopids, has dentition along the pleotelson posterior margin. Moreover, the males of *Andhracoides* species lack the enormously elongate uropodal exopods possessed by *Nichollsia* adult males. The exopod is reverse to this condition, with the male exopod being shorter than in the female (Fig. 9).

A phylogenetic analysis of 65 phreatoicidean species and 421 characters (Wilson, in progress; data available on request; see Wilson, 2008 for details) finds that *Andhracoides* gen. nov., is sister to *Nichollsia*, as expected, and this group forms a clade with the two species of *Pilbarophreatoicus* Knott and Halse (one undescribed). Additionally, the hypsimetopid part of the cladogram is similar to that shown in Wilson (2008: fig. 4) but the position of *Hyperoedespitus* is moved to be sister to the *Phreatoicoides*–*Hypsimetopus* clade and the Pilbaran-Indian clade (*Andhracoides*, *Nichollsia*, *Pilbarophreatoicus*) emerges basally in the hypsimetopid clade. These results support the biogeographic relationship between India and Western Australia, if based on tectonic vicariance, suggests that these lineages are older than 135 million years (Wilson, 2008, table 2).

In his introduction, Gupta (1989:1) writes "In a personal communication to Dr. K. K. Tiwari, Prof. P. J. Sanje-eva Raj of Madras Christian College, Tarnbaram (Madras), informs that he has material of phreatoicid isopods from Andhra Pradesh (locality not revealed) in South India obtained during deep drilling operations for boring tube wells." This is almost certainly the first report of *Andhracoides* gen. nov. but further details have not appeared in the published literature. A conference abstract (Messana, 2004) mentions a species from Andhra Pradesh referred to *Nichollsia*; this species belongs to *Andhracoides* but is a different species with a heavily setose pleotelson. Its locality is reported to be Belum Cave (Messana, pers. comm.). Gupta (1989) mentions that *Nichollsia* has been recorded from a number of isolated localities in Uttar Pradesh and Bihar in the Gangetic Plains. These two genera appear to be isolated by major river systems in these two states.

Andhracoides shabuddin sp. nov.

(Figs 2–9)

Type material. Holotype male, AM P.81105, bl 22.6 mm, 27.xii.2008, here designated. Paratypes: female, AM P.81106, bl 16.2, 27.xii.2008; male, AM P.81107, bl 26.0 mm, 27.xii.2008, SEM; female, AM P.81108, 16.i.2009, SEM & DNA; male, AM P.84983, bl 22.5 mm, pleopods dissected, 27.xii.2008; 7 specimens, AM P.84984, 16.i.2009; 9 specimens, P.84985, 16.i.2009; 8 specimens, ZSI C 5912/2, 27.xii.2008; 6 specimens, ZSI C 5913/2, 27.xii.2008.

Type locality. India, Andhra Pradesh State, ~8 km from Piduguralla, Guntur District, Guthikonda Cave, 16°23.7067' N, 79°49.6495' E, elevation 160 m, freshwater pool in cave, coll. Y. R. Reddy and party, 27.xii.2008 & 16.i.2009.

Etymology. The new species is named for Mr. Shabuddin Shaik, an enthusiastic M. Sc. (Zoology) student at Acharya Nagarjuna University during 2008–2010, who collected the first sample of this species. The name is proposed here as a noun in apposition to the generic name.

Description. Colouration cuticle white, without pigment. *Head* (Figs 2C, 3A–B, E). Length subequal to width in dorsal view; lateral profile of dorsal surface smoothly curved; width 1.2–1.5 pereonite 1 width (M, AM P.81107; F, AM P.81108; H); surface smooth and shiny; setae absent. Cervical groove straight, extending nearly to dorsal margin of head. Mandibular (genal or cheek) groove absent. Mandibular notch present. Clypeal notch present. Antennal notch shallow, without posterior extension. Frontal process above antennula present. Mouth field in both sexes adjacent to posterior margin of head and anterior margin of pereonite 1.

Pereon (Fig. 2A–C, E). Width near head width; surface smooth; setae on dorsal surface absent. Pereonite 1 in dorsal view wider than medial length, width 0.51 length (H). Pereonites 2–7 in dorsal view anteriorly longer than wide decreasing posteriorly to wider than long, relative to pereonite 2 length:width ratios 1.02, 1.15, 1.05, 0.95, 0.71, respectively. Sternal processes occurring on sternites 1–7 (weak keel).

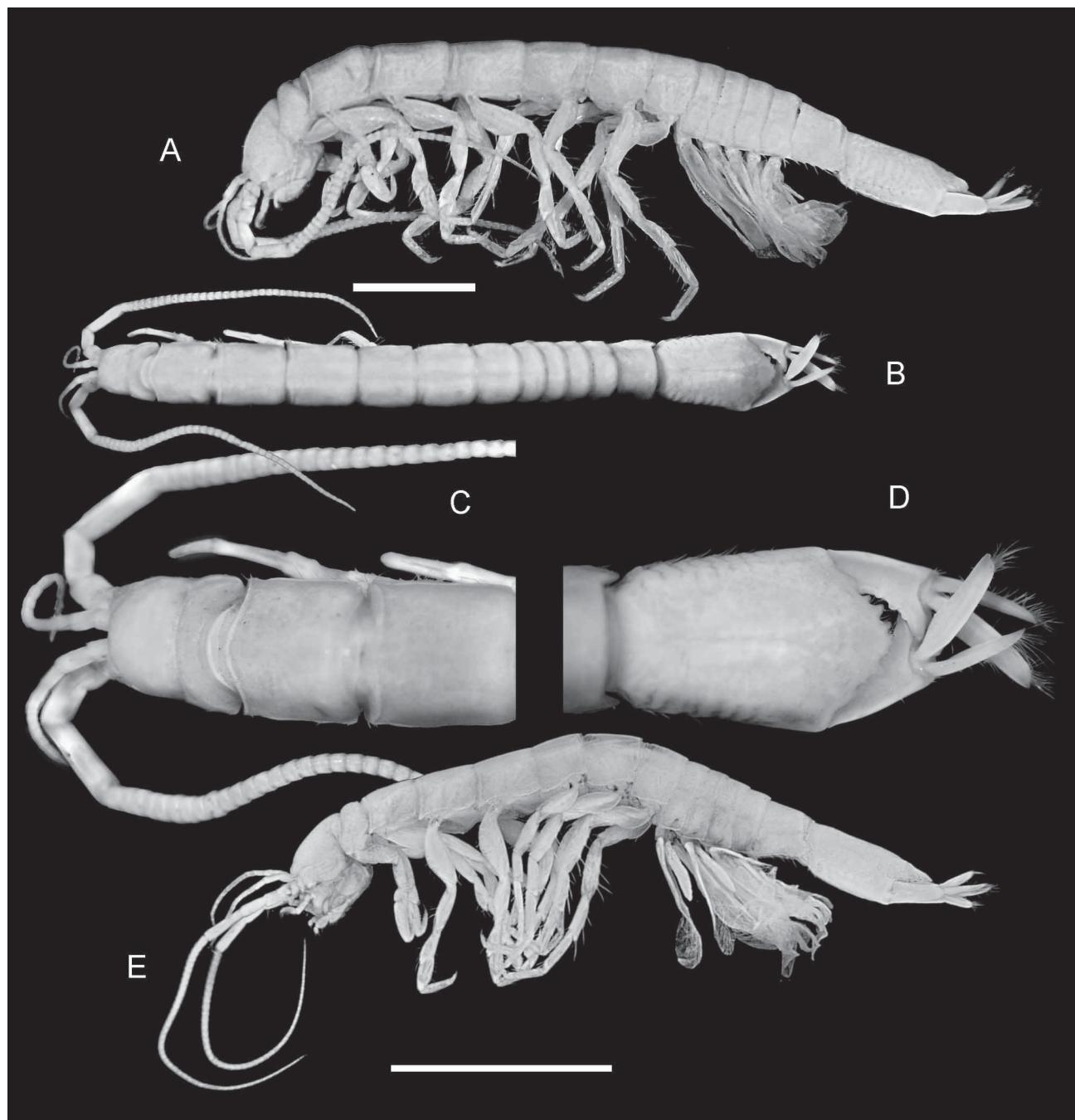


FIGURE 2. *Andhracoides shabuddin gen. nov., sp. nov.* Holotype male, AM P.81105: A, lateral view; B, dorsal view; C, head and pereonites 1–3; D, pleotelson; E, paratype female, AM P.81106, lateral view. Scale bars = 5 mm.

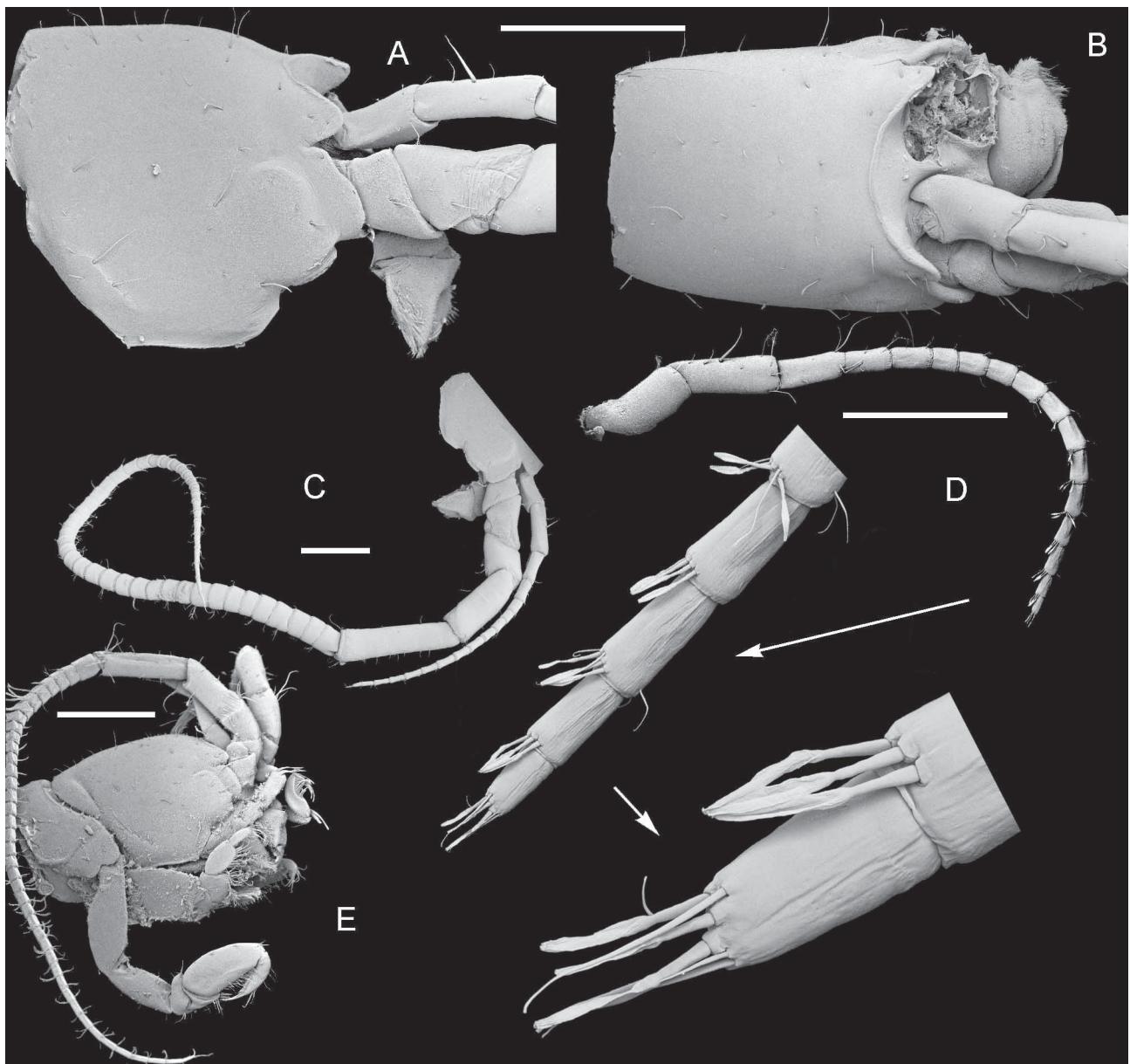


FIGURE 3. *Andhracoides shabuddin* gen. nov., sp. nov., head. Paratype male, AM P.81107: A, head, lateral view; B, dorsal view; C, antennula and antenna; D, antennula with enlargements of distal articles; E, paratype female, AM P.81108, head and pereopod I lateral view. Scale bars = 1 mm.

Pleonites (Fig. 2A–B, E). In lateral view, pleonite 1 pleura near depth of pleurae of pleonites 2–5. In dorsal view, pleonite 2–4 respective lengths more than half the length of pleonite 5, 1–4 relative lengths subequal, 1–4 width 0.62 composite length in dorsal view. Pleonite 1–5 length:width ratios 0.42, 0.42, 0.42, 0.42, 0.69, respectively; depth ratios with pereonite 7 depth, respectively: 1.09; 1.05; 1; 0.96; 0.82. Pleonite 5 ventral margin constricting posteriorly, distance to dorsal margin noticeably greater anteriorly than posteriorly.

Pleotelson (Figs 2D, 9A, C–D, F–H). Dorsal surface in lateral view sparsely covered with fine setae, length 1.25 width; lateral length 0.17–0.195 body length (H, F P.81106), lateral length 2.6 depth; depth 0.72 pereonite 7 depth; ventral margin anterior to uropods 3.6–4.1 width of uropodal insertion (H; AM P.81107), with fine setae, posterior seta length subequal to anterior adjacent setae. Posterolateral margin with 4–5 teeth on each side (AM P.81107 with tiny terminal tooth); teeth rounded in cross-section (with whorls of microscopic subdenticles).

Antennula (Figs 2E, 3C–D). Length 0.16–0.19 body length (F, M), with 17–18 articles (M, F). Article 5 length:width 0.86–1.8 (F, M). Article 6 length:width 1.2–1.3 (M, F). Aesthetascs occurring on distal 9 articles in male, 7 in female, 3 per article. Terminal article length 1.9 width (M), length 0.025 antennula total length (M).

Antenna (Figs 2A, E, 3C, E). Length 0.51–0.58 body length (M, F). Article 5 longer than article 4, 6 subequal to articles 4 and 5 combined. Flagellum length 0.73–0.76 total antenna length (F P.81106, H), with 43–49 articles (H, F P.81106).

Mouth field (M P.81107; Figs 3, 4). Clypeus medial margin broadly curved dorsally, concave under antennae, slightly curling dorsally and anteriorly at mandibular attachment, deeper on left side than on right, width 0.68 head width (M P.81107). Labrum dorsal margin with clypeus linear, sloping ventrally to left side, ventral margin scalloped, with many long cuticular hairs, frontolateral fields with patch of fine cuticular hairs, labrum dorsal margin narrower than clypeus. Paragnaths lateral lobes smooth arc laterally, distally angular (approximately 90°), medially curving proximally to straight margin between lobes; medial lobe open, not convoluted, not projecting, medial cuticular hairs coarse and elongate, becoming shorter proximally, ventrolateral cuticular hairs thinner and longer than medial hairs.

Mandible (M P.81107; Fig. 4A–E). Palp length 1.2 mandible length; article 3 with more than 5 setae on medial margin, distal margins with 34 setae (in 2 rows), setae on margin finely spinulate, medial surface additional setae absent, medial surface lacking cuticular hairs or cuticular combs; article 2 longitudinal row of setae absent, separate distal group of setae present; articles 1–2 with single groups of setae on distolateral margins, article 2 with 6 elongate distally setulate setae. Left spine row with 8 spines, 2 of which bifurcate. Right spine row with 7 spines, 1 of which bifurcate. Molar process without teeth, complex setulate spines forming posterior row.

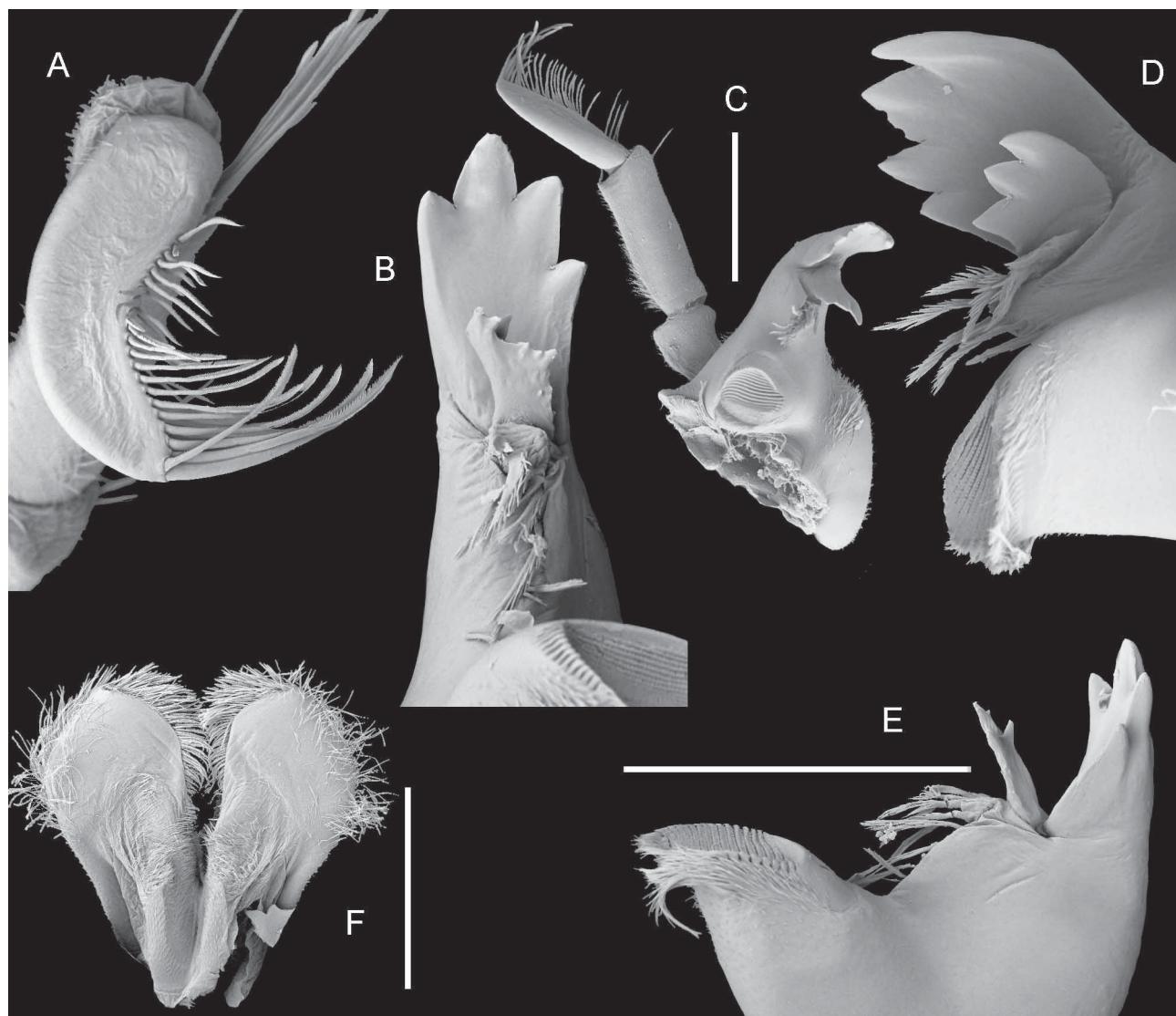


FIGURE 4. *Andhracoides shabuddin gen. nov., sp. nov.* Paratype male, AM P.81107. Mandible: A, left palp, dorsal view; B, right gnathal tip, medial view; C, left, medial view; D, left gnathal margin, dorsal view; E, right gnathal margin, ventral view; F, paragnath, ventral view. Scale bars = 0.5 mm.

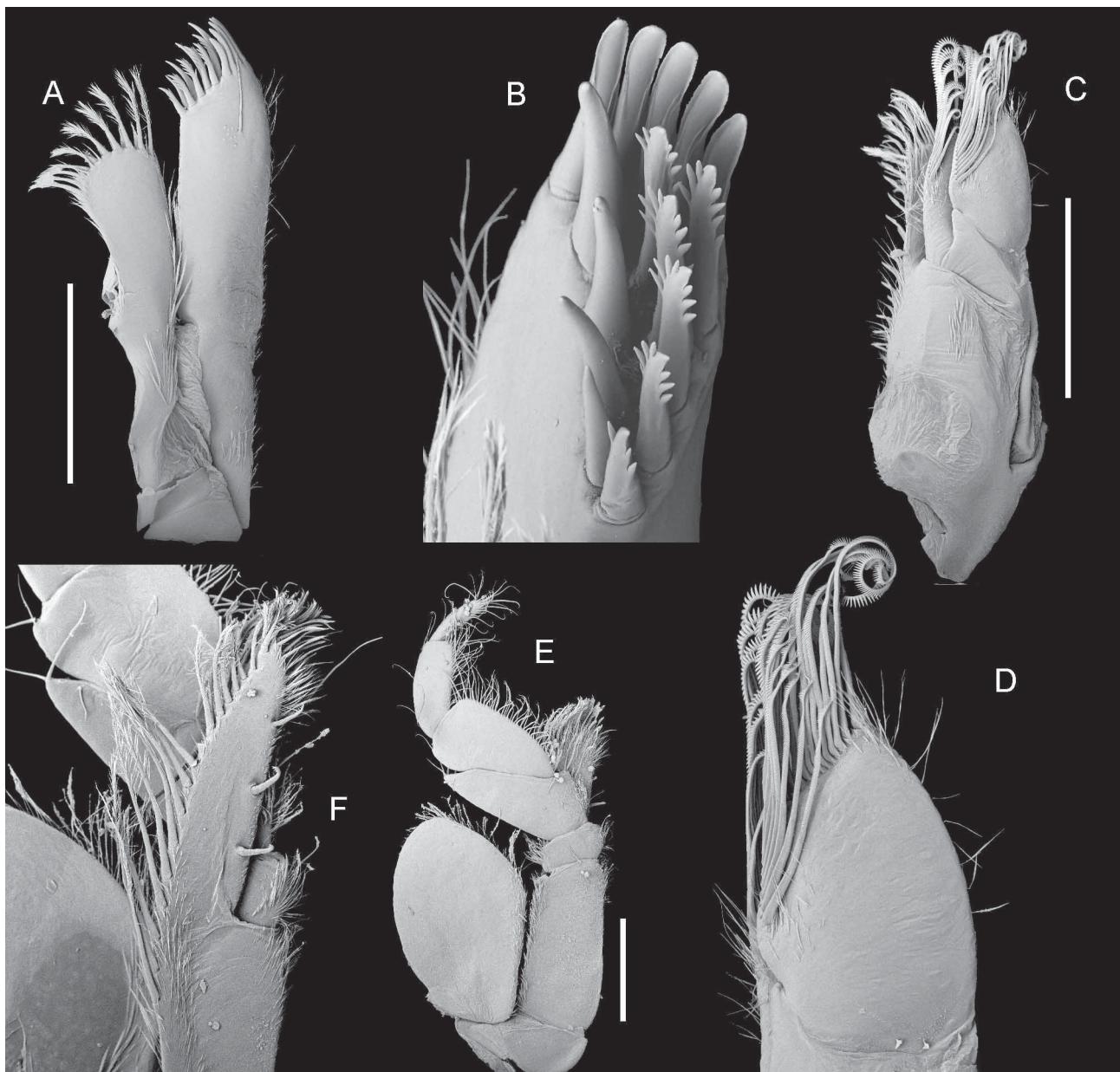


FIGURE 5. *Andhracoides shabuddin gen. nov., sp. nov.* Paratype male, AM P.81107, mouthparts. A–B, left maxillula, ventral and medial view of lateral lobe; C–D, left maxilla, ventral view and ventrolateral view of lateral lobe; E–F, right maxilliped, ventral view and medial view of endite. Scale bars = 0.5 mm.

Maxillula (M AM P.81107; Fig. 5A–B). Medial lobe length 0.74 lateral lobe length, width subequal to lateral lobe width 0.97 lateral lobe width, with 10 pappose setae, with 3 simple 'accessory setae' on distomedial margin; short weakly setulate seta on distal tip absent. Lateral lobe distal margin with 6 denticulate robust setae, with 9 smooth robust setae, distal setal row with 5 robust setae; ventral face with 1 plumose seta, additional plumose seta absent.

Maxilla (M AM P.81107; Fig. 5C–D). Medial lobe width 0.74 outer lateral lobe width; proximal setae smoothly continuous in row with distal setae; setae in ventral basal rows elongate and finely pappose; setae in dorsal basal row well-separated, with proximal smooth setae grading into distally setulose setae; setae in distal row pappose. Outer lateral lobe length subequal to inner lateral lobe, width subequal to inner lateral lobe, distal margin setal row with two angles, transverse to lateral margin and oblique on medial margin; lateral lobes with bidenticulate setae on distal tips and on medial margin, 22 long setae on outer lateral lobe, 20 setae on inner lateral lobe (approximately; obscured by outer lateral lobe).

Maxilliped (M AM P.81107; Fig. 5E–F). Epipod length:width 1.6, distal tip rounded. Endite medial length:total basis length 0.44; medial margin with 3 coupling hooks on left side, 3 on right side; distal margin with fine setae in dense fringe; ventral surface with medially grouped short setae; distal tip with 15 subdistal biserrate setae on ventral surface (approximately; in dense group of long cuticular hairs); dorsal ridge with 17 large distally denticulate plumose setae. Palp insertion on basis without adjacent simple or plumose setae; length:basis length 1.1; width across articles 2–3:endite width 2.1; article 5 length:width 1.6, article 5 length:article 4 length 0.75.



FIGURE 6. *Andhracoides shabuddin gen. nov., sp. nov.*, anterior pereopods. A, paratype female, AM P.81108, pereopod I, lateral view with enlargement of palm region, medial view. Paratype male, AM P.81107: B, pereopod I, lateral view with enlargement of palm region; C–E, pereopods II–IV, lateral view with enlargements of dactylus and propodus. Scale bars = 1 mm.

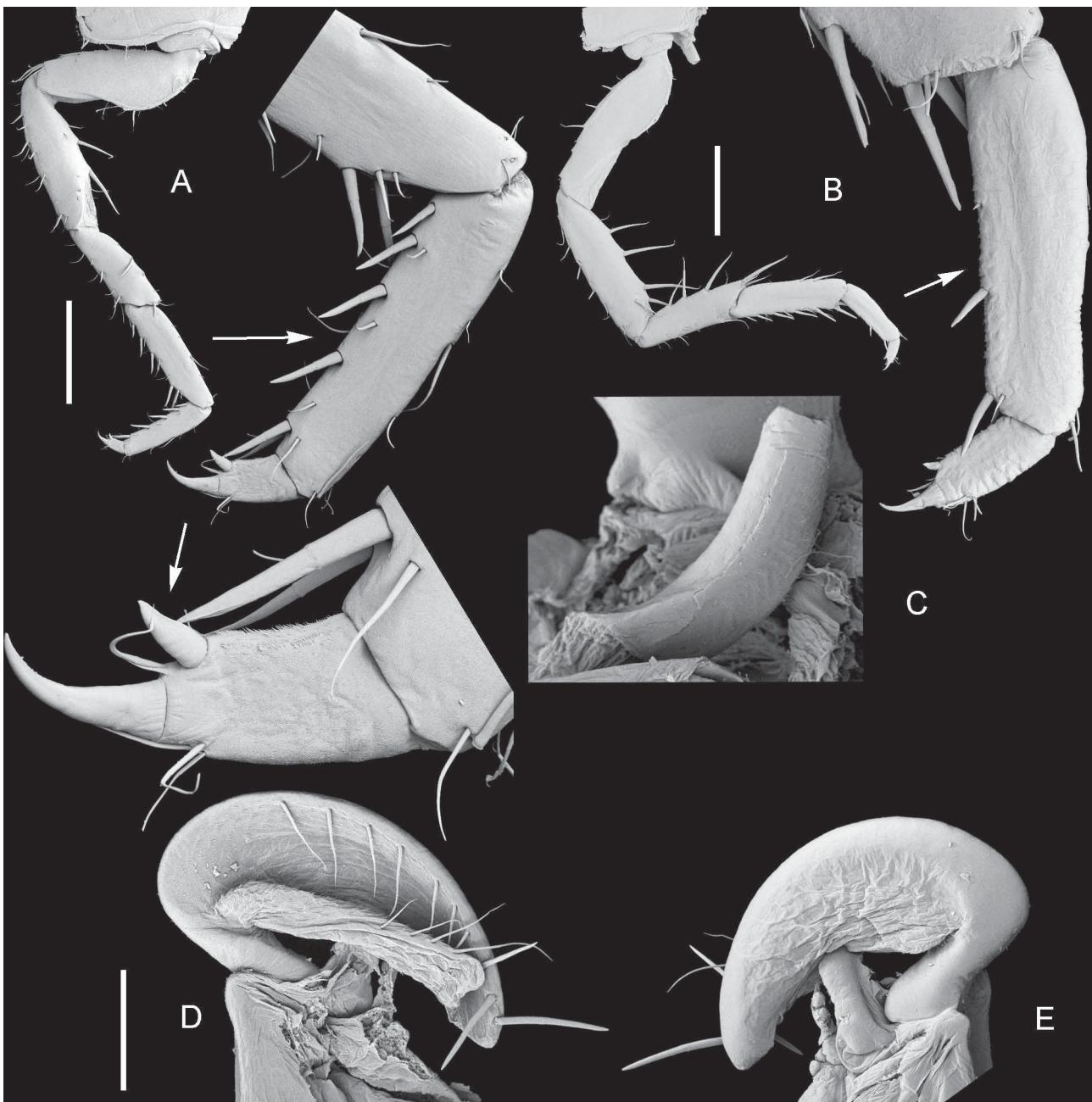


FIGURE 7. *Andhracoides shabuddin gen. nov., sp. nov.* Paratype male, AM P.81107: A, right pereopod V, right lateral view with enlargement of propodus and dactylus; B, pereopod VII, lateral view with enlargement of propodus and dactylus; C, penes, right side, posteromedial view; D–E, appendix masculina, dorsal and ventral views. Scale bars: A–C = 1 mm; D–E = 0.2 mm.

Pereopod I (M AM P.81107; F AM P.81108; Fig. 6A–B). Length:body length 0.24 (H), 0.25 (F). Dactylus length:propodus ventral margin length 1.3 (in both sexes); lateral surface with row of fine setae along axis; ventro-distal margin with row of thin scale-like spines, along 0.46–0.5 (F, M) total length; claw length:dactylus length 0.29–0.35 (M, F); dactylus with 1 distal accessory claw, flattened transversely, sharply acute, length approximately 0.25 dorsal claw length; without distal accessory spines. Propodus length:pereopod length 0.23, 0.21 (M, F); length:width 2.18, 2.07 (M, F); dorsal margin setae in several groups between proximal and distal margin, with 4 setae (excluding distal group); proximal region not protruding in either sex. Propodal palm without stout denticulate setae, with 5–6 (F, M) stout robust conical simple setae, setal ridge absent. Merus distodorsal margin with 1 or 2 robust simple setae. Basis length:width 2.17–2.18 (M, F); 1 dorsal setae in male positioned proximally (1–2 minor setae anterior margin); ventrodistal margin with 1 elongate seta, shorter than ischium.

Pereopods II–III (Fig. 6C–D). Penicillate setae in row of 6 on lateral side of basis dorsal ridge. Dactylus distal accessory claw distally flattened and blade-like, length 0.41 length of dorsal claw; dactylus ventral margin without spines. Propodus and carpus ventral margin setae robust. Ischium dorsal margin with 5 simple setae. Basis dorsal ridge in cross-section angular but not forming distinct plate.

Pereopod II ratios, male (AM P.81107) and female (ZSI C 5912/2), respectively. Length:body length 0.28, 0.3; dactylus length:propodus length 0.44, 0.62; dactylus primary claw length:dactylar length 0.53, 0.53; propodus length:pereopod length 0.14, 0.15; propodus length:width 3.66, 3.54; carpus length:pereopod length 0.15, 0.16; carpus length:width 2.14, 2.66; basis length:pereopod length 0.29, 0.27; basis length:width 3.04, 2.75.



FIGURE 8. *Andhracoides shabuddin gen. nov., sp. nov.* Paratype male, AM P.84983, pleopods, dorsal view. A, pleopod I; B–C, pleopod II, with enlargement of appendix masculina; D–E, pleopods III–V. Scale bar = 1 mm.

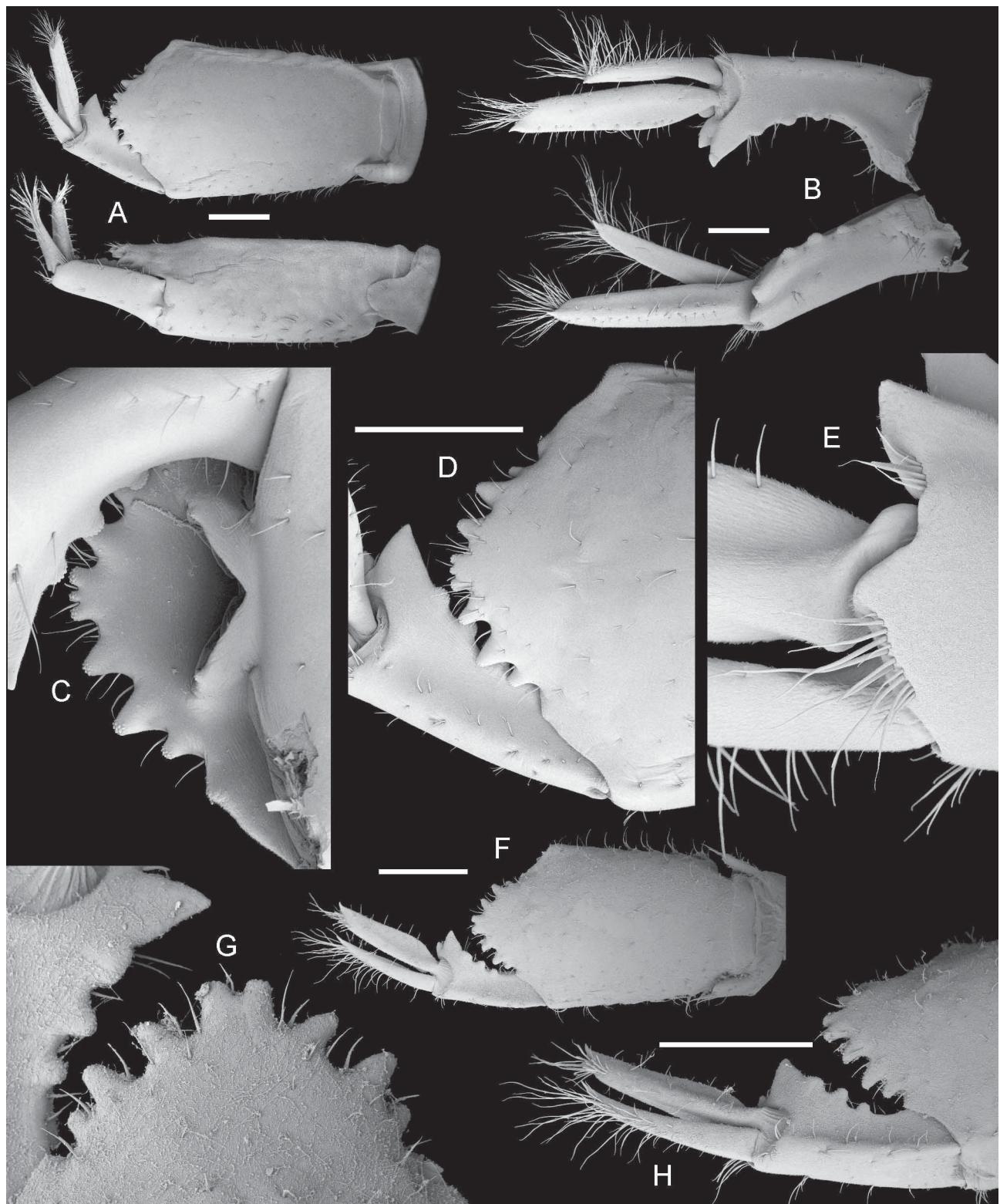


FIGURE 9. *Andhracoides shabuddin gen. nov., sp. nov.*, pleotelson and uropods. Paratype male, AM P.81107: A, pleotelson dorsal and lateral views; B, left uropod, dorsal and medial views; C, pleotelson distal margin and anus, ventral view; D, pleotelson distal margin and uropod protopod, dorsal view; E, distoventral margin of left uropod protopod. Paratype female, AM P.81108: F, pleotelson, dorsal view; G, pleotelson distal margin and uropod protopod, dorsal view; H, pleotelson and right uropod, dorsolateral oblique view. Scale bars = 1mm.

Pereopod III ratios, male (AM P.81107) and female (ZSI C 5912/2), respectively. Length:body length 0.28, 0.33; dactylus length:propodus length 0.41, 0.45; dactylus primary claw length:dactylar length 0.56, 0.48; propo-

dus length:pereopod length 0.13, 0.12; propodus length:width 3.52, 3.61; carpus length:pereopod length 0.14, 0.14; carpus length:width 2.4, 2.12; basis length:pereopod length 0.31, 0.29; basis length:width 2.96, 2.71.

Pereopod IV (AM P.81107, Fig. 6E). Penicillate setae present in both sexes, occurring on dorsal margin of basis. Dactylus distal accessory claw approximately 0.33 length of primary claw. Propodus setae on ventral margin robust. Carpus setae on ventral margin in both sexes robust. Ischium posterodistal margin with 5 setae in male. Basis dorsal ridge with 4–5 setae (F, M; approximately), positioned proximally.

Pereopod IV ratios, male (AM P.81107) and female (ZSI C 5912/2), respectively. Length:body length 0.3, 0.33; propodus length:pereopod length 0.15, 0.11; propodus length:width 4.25, 3.11; carpus length:pereopod length 0.14, 0.14; basis length:width 2.8, 2.8.

Pereopods V–VII (AM P.81107, Fig. 7A–B). Penicillate setae on dorsal ridge of basis, or dorsodistally on carpus, or dorsodistally on propodus. Dactylus accessory claw robust, conical, length nearly half length of primary claw. Propodus distal margins with 5–7 elongate robust setae. Ischium dorsal margin with 4–6 simple setae (increasing in length posteriorly). Basis dorsal ridge with no large setae. *Penes* (Fig. 7C) on pereopod VII coxa extending near midline; distally tubular; distal tip truncate.

Pereopod V ratios, male (AM P.81107) and female (ZSI C 5912/2), respectively. Length:body length 0.25, 0.29; dactylus claw length:dactylar length 0.45, 0.41; propodus length:pereopod length 0.13, 0.13; carpus length:pereopod length 0.18, 0.17; basis length:width 2.66, 2.43.

Pereopod VI ratios, male (AM P.81107) and female (ZSI C 5912/2), respectively. Length:body length 0.31, 0.36; dactylus claw length:dactylar length 0.44, 0.44; propodus length:pereopod length 0.13, 0.15; carpus length:pereopod length 0.19, 0.18; basis length:width 2.99, 2.7.

Pereopod VII ratios, male (AM P.81107) and female (ZSI C 5912/2), respectively. Length:body length 0.28, 0.38; dactylus claw length:dactylar length 0.37, 0.33; propodus length:pereopod length 0.11, 0.15; carpus length:pereopod length 0.18, 0.16; basis length:width 3.0, 2.9.

Pleopods (AM P.84983, Fig. 8). Protopods II–V medial margins with small projections, with simple setae only in small group. Pleopod I exopod broadest distally, distal margin rounded, medial margin convex, divergent from lateral margin proximally, dorsal surface lacking setae. Pleopod II endopod appendix masculina (Fig. 7D–E, 8B–C) length 0.14 pleopod length; distal tip not extending beyond half length of exopod; proximal half of shaft forming elongate channel, groove open distally; distal tip acutely rounded; elongate rod-like setae on medial and lateral margins (2, 1, respectively); lateral margin with 4 setae; medial margin with 10 setae.

Pleopod ratios (M AM P.84983). *Pleopod I* length:body length 0.17; exopod length:width 1.94; endopod length:width 2.01; endopod length:exopod length 0.45. *Pleopod II* length:body length 0.17; exopod length:width 2.13; exopod length of distal article:exopod length 0.44; endopod length:width 2.5; endopod length:exopod length 0.49. *Pleopod III* length:body length 0.16; exopod length:width 1.97; exopod length of distal article:exopod length 0.46; endopod length:width 2.14; endopod length:exopod length 0.47. *Pleopod IV* length:body length 0.15; exopod length:width 1.9; exopod length of distal article:exopod length 0.48; endopod length:width 2.33; endopod length:exopod length 0.49. *Pleopod V* length:body length 0.15; exopod length:width 1.87; exopod length of distal article:exopod length 0.49; endopod length:width 2.1; endopod length:exopod length 0.43.

Uropod (AM P. Fig. 9A–B, D–E, F–H). Protopod extending posterior to pleotelson apex; dorsomedial ridge produced, spur-like, dorsomedial ridge medially directed, each margin with 3 broad denticles, without setae; dorsolateral margin setae fine and simple; distoventral margin without robust or spinose setae. Rami distal tips pointed; cross-sectional shape flattened on dorsal surface only. Endopod and exopod dorsal margins without robust setae in either sex.

Uropod ratios, male (AM P.81107) and female (AM P.81108), respectively. Total length:pleotelson length 0.73, 0.81. Protopod length:width 1.97, 1.68; length: uropod total length 0.59, 0.49. Exopod length: endopod length 0.66, 0.92.

Distribution. Peninsular India: in the state of Andhra Pradesh, found in caves and in wells.

Remarks. Although the data have not been compiled on the more limited specimens at hand, we have observed that the undescribed species of this genus differ from *Andhracoides shabuddin* sp. nov. in the robustness of the pleotelson and uropods, and in dorsal setation, which is largely lacking in this species. Other species are much more heavily setose and therefore are easily identified as different from *Andhracoides shabuddin* sp. nov.

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